

WHAT IS CLAIMED IS:

1. An exhaust gas processing method characterized by comprising:

a first process of making exhaust gas flow through
5 coolant to cool it to such a first temperature as to
liquefy or solidify nitrogen oxides without solidifying
carbon dioxide, thereby liquefying or solidifying
nitrogen oxides as toxic gas components contained in the
exhaust gas to separate them from the exhaust gas; and

10 a second process of cooling the exhaust gas to such
a second temperature as to solidify carbon dioxide,
thereby solidifying carbon dioxide contained in the
exhaust gas to separate it from the exhaust gas.

15 2. The exhaust gas processing method according to claim
1, characterized by comprising:

a first process of making exhaust gas flow through
coolant to cool it to such a first temperature as to
liquefy or solidify nitrogen oxides and sulfur oxides
20 without solidifying carbon dioxide, thereby liquefying
or solidifying nitrogen oxides and sulfur oxides as toxic
gas components contained in the exhaust gas to separate
them from the exhaust gas; and

a second process of cooling the exhaust gas to such
25 a second temperature as to solidify carbon dioxide,
thereby solidifying carbon dioxide contained in the
exhaust gas to separate it from the exhaust gas.

3. The exhaust gas processing method according to claim
30 2, characterized by comprising:

a process of raising in temperature the toxic gas components separated from the exhaust gas by the first process to such a temperature as to vaporize the coolant but not the toxic gas components, thereby separating the
5 toxic gas components and the coolant.

4. The exhaust gas processing method according to claim 3, characterized by comprising:

a process of circulating the coolant separated from
10 the toxic gas components as the coolant through which the exhaust gas is made to flow.

5. The exhaust gas processing method according to any one of claims 2 to 4, characterized by comprising:

15 a process of raising in temperature the toxic gas components separated from the exhaust gas by the first process to such a temperature as to vaporize sulfur oxides but not nitrogen oxides, thereby separating the sulfur oxides and nitrogen oxides included in the toxic
20 gas components.

6. The exhaust gas processing method according to any one of claims 2 to 5, characterized in that the coolant includes any one of dimethyl ether, methanol, ethanol,
25 toluene, and ethyl benzene.

7. The exhaust gas processing method according to any one of claims 2 to 6, characterized in that the first process includes a process of separating moisture
30 contained in the exhaust gas from the exhaust gas.

8. The exhaust gas processing method according to any one of claims 2 to 7, characterized in that the second process includes a process of liquefying the solidified
5 carbon dioxide (dry ice).

9. The exhaust gas processing method according to any one of claims 2 to 8, characterized in that a preprocess of removing moisture, toxic gas components, and dust
10 contained in the exhaust gas through heat exchange with water after the exhaust gas is cooled to about room temperature is executed before the first process.

10. An exhaust gas processing system characterized by
15 comprising:

a first apparatus which performs a process of making exhaust gas flow through coolant to cool it to such a first temperature as to liquefy or solidify nitrogen oxides without solidifying carbon dioxide, thereby
20 liquefying or solidifying nitrogen oxides as toxic gas components contained in the exhaust gas to separate them from the exhaust gas; and

a second apparatus which performs a process of cooling the exhaust gas to such a second temperature as
25 to solidify carbon dioxide, thereby solidifying carbon dioxide contained in the exhaust gas to separate it from the exhaust gas.

11. The exhaust gas processing system according to claim
30 10, characterized by comprising:

a first apparatus which performs a process of making exhaust gas flow through coolant to cool it to such a first temperature as to liquefy or solidify nitrogen oxides and sulfur oxides without solidifying carbon dioxide, thereby liquefying or solidifying nitrogen oxides and sulfur oxides as toxic gas components contained in the exhaust gas to separate them from the exhaust gas; and

a second apparatus which performs a process of cooling the exhaust gas to such a second temperature as to solidify carbon dioxide, thereby solidifying carbon dioxide contained in the exhaust gas to separate it from the exhaust gas.

12. The exhaust gas processing system according to claim 11, characterized by comprising:

an apparatus which raises in temperature the toxic gas components separated from the exhaust gas by the first apparatus to such a temperature as to vaporize the coolant, which is mixed with the toxic gas components, but not the toxic gas components, thereby separating the toxic gas components and the coolant.

13. The exhaust gas processing system according to claim 11, characterized by comprising:

an apparatus which circulates the coolant separated from the toxic gas components as the coolant through which the exhaust gas is made to flow.

14. The exhaust gas processing system according to any

one of claims 11 to 13, characterized by comprising:

an apparatus which raises in temperature the toxic gas components separated from the exhaust gas by the first apparatus to such a temperature as to vaporize sulfur oxides but not nitrogen oxides, thereby separating the sulfur oxides and nitrogen oxides included in the toxic gas components.

15. The exhaust gas processing system according to any one of claims 11 to 14, characterized in that the coolant includes any one of dimethyl ether, methanol, ethanol, toluene, and ethyl benzene.

16. The exhaust gas processing system according to any one of claims 11 to 15, characterized in that the first apparatus comprises an apparatus which separates moisture contained in the exhaust gas from the exhaust gas.

17. The exhaust gas processing system according to any one of claims 11 to 16, characterized in that the second apparatus comprises an apparatus which liquefies the solidified carbon dioxide (dry ice).

18. The exhaust gas processing system according to any one of claims 11 to 17, characterized by comprising:

an apparatus which performs a preprocess of removing moisture, toxic gas components, and dust contained in the exhaust gas through heat exchange with water after the exhaust gas is cooled to about room temperature,

before the process to be performed by the first apparatus.

19. An exhaust gas processing method characterized by
5 comprising:

a first process of making exhaust gas exhausted from an LNG burning boiler flow through coolant to cool it to such a first temperature as to liquefy or solidify nitrogen oxides without solidifying carbon dioxide,
10 thereby liquefying or solidifying nitrogen oxides as toxic gas components contained in the exhaust gas to separate them from the exhaust gas; and

a second process of cooling the exhaust gas to such a second temperature as to solidify carbon dioxide,
15 thereby solidifying carbon dioxide contained in the exhaust gas to separate it from the exhaust gas.

20. The exhaust gas processing method according to claim 19, characterized by comprising:

20 a process of introducing the nitrogen oxides solidified by the first process into a solid-liquid separator, thus separating the nitrogen oxides and the coolant.

25 21. The exhaust gas processing method according to claim 20, characterized by comprising:

a process of raising in temperature the liquid separated by the solid-liquid separator to such a temperature as to vaporize the coolant but not the toxic
30 gas components, thereby separating the coolant.

22. The exhaust gas processing method according to claim 21, characterized by comprising:

5 a process of circulating the coolant separated from the liquid as the coolant through which the exhaust gas is made to flow.

23. The exhaust gas processing method according to any one of claims 19 to 22, characterized in that the coolant
10 includes any one of dimethyl ether, methanol, ethanol, toluene, and ethyl benzene.

24. The exhaust gas processing method according to any one of claims 19 to 23, characterized in that the first
15 process includes a process of separating moisture contained in the exhaust gas from the exhaust gas.

25. The exhaust gas processing method according to any one of claims 19 to 24, characterized in that the second
20 process includes a process of liquefying the solidified carbon dioxide (dry ice).

26. The exhaust gas processing method according to any one of claims 19 to 25, characterized in that a preprocess
25 of removing moisture and toxic gas components contained in the exhaust gas through heat exchange with water after the exhaust gas is cooled to about room temperature is executed before the first process.

30 27. The exhaust gas processing method according to any

one of claims 19 to 26, characterized in that the exhaust gas or the coolant of at least one of the first and second processes is cooled due to the heat of vaporization that is produced when LNG is used as gas fuel.

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28. An exhaust gas processing system characterized by comprising:

a first apparatus which performs a process of making exhaust gas exhausted from an LNG burning boiler flow
10 through coolant to cool it to such a first temperature as to liquidize or solidify nitrogen oxides without solidifying carbon dioxide, thereby liquidizing or solidifying nitrogen oxides as toxic gas components contained in the exhaust gas to separate them from the
15 exhaust gas; and

a second apparatus which performs a process of cooling the exhaust gas to such a second temperature as to solidify carbon dioxide, thereby solidifying carbon dioxide contained in the exhaust gas to separate it from
20 the exhaust gas.

29. The exhaust gas processing system according to claim 28, characterized by comprising:

an apparatus which introduces the nitrogen oxides
25 solidified by the first apparatus into a solid-liquid separator, thus separating the nitrogen oxides and the coolant.

30. The exhaust gas processing system according to claim
30 29, characterized by comprising:

an apparatus which raises in temperature the liquid separated by the solid-liquid separator to such a temperature as to vaporize the coolant but not the toxic gas components, thereby separating the coolant.

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31. The exhaust gas processing system according to claim 30, characterized by comprising:

an apparatus which circulates the coolant separated from the liquid as the coolant through which the exhaust
10 gas is made to flow.

32. The exhaust gas processing system according to any one of claims 28 to 31, characterized in that the coolant includes any one of dimethyl ether, methanol, ethanol,
15 toluene, and ethyl benzene.

33. The exhaust gas processing system according to any one of claims 28 to 32, characterized in that the first apparatus comprises an apparatus which separates
20 moisture contained in the exhaust gas from the exhaust gas.

34. The exhaust gas processing system according to any one of claims 28 to 33, characterized in that the second
25 apparatus comprises an apparatus which liquefies the solidified carbon dioxide (dry ice).

35. The exhaust gas processing system according to any one of claims 28 to 34, characterized by comprising:
30 an apparatus which performs a preprocess of removing

moisture and toxic gas components contained in the exhaust gas through heat exchange with water after the exhaust gas is cooled to about room temperature, before the process to be performed by the first apparatus.

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36. The exhaust gas processing system according to any one of claims 28 to 35, characterized in that the exhaust gas or the coolant in at least one of the first and second apparatuses is cooled due to the heat of vaporization that is produced when LNG is used as gas fuel.

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37. An exhaust gas processing system characterized by comprising:

a first apparatus which makes exhaust gas flow through coolant to cool it to such a temperature as to liquefy or solidify nitrogen oxides and sulfur oxides without solidifying carbon dioxide, thereby liquefying or solidifying nitrogen oxides and sulfur oxides as toxic gas components contained in the exhaust gas to separate them from the exhaust gas; and

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a second apparatus which makes the exhaust gas having had the nitrogen oxides and sulfur oxides removed flow through a pressure-resistant container to cool and solidify carbon dioxide, closes the pressure-resistant container air-tightly, raises in temperature the solidified carbon dioxide to vaporize, liquefies the carbon dioxide by pressure increase due to the vaporization of the carbon dioxide in the pressure-resistant container, and discharges the liquefied carbon dioxide outside the pressure-resistant

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container.

38. The exhaust gas processing system according to claim 37, characterized by comprising:

5 an apparatus which raises in temperature the toxic gas components separated from the exhaust gas by the first apparatus to such a temperature as to vaporize the coolant, which is mixed with the toxic gas components, but not the toxic gas components, thereby separating the
10 toxic gas components and the coolant.

39. The exhaust gas processing system according to claim 37 or 38, characterized by comprising:

15 an apparatus which raises in temperature the toxic gas components separated from the exhaust gas by the first apparatus to such a temperature as to vaporize sulfur oxides but not nitrogen oxides, thereby separating the sulfur oxides and nitrogen oxides included in the toxic gas components.

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40. An exhaust gas processing system characterized by comprising:

25 a first apparatus which performs a process of making exhaust gas exhausted from an LNG burning boiler flow through coolant to cool it to such a first temperature as to liquefy or solidify nitrogen oxides without solidifying carbon dioxide, thereby liquefying or solidifying nitrogen oxides as toxic gas components contained in the exhaust gas to separate them from the
30 exhaust gas; and

a second apparatus which makes the exhaust gas having had the nitrogen oxides removed flow through a pressure-resistant container to cool and solidify carbon dioxide, closes the pressure-resistant container
5 air-tightly, raises in temperature the solidified carbon dioxide to vaporize, liquefies the carbon dioxide by pressure increase due to the vaporization of the carbon dioxide in the pressure-resistant container, and discharges the liquefied carbon dioxide outside the
10 pressure-resistant container.

41. The exhaust gas processing system according to claim 40, characterized by comprising:

an apparatus which introduces the nitrogen oxides
15 solidified by the first process into a solid-liquid separator, thus separating the nitrogen oxides and the coolant.

42. The exhaust gas processing system according to claim
20 41, characterized by comprising:

an apparatus which raises in temperature the liquid separated by the solid-liquid separator to such a temperature as to vaporize the coolant but not the toxic gas components, thereby separating the coolant.
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43. The exhaust gas processing system according to any one of claims 37 to 42, characterized in that the coolant includes any one of dimethyl ether, methanol, ethanol, toluene, and ethyl benzene.
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44. The exhaust gas processing system according to any one of claims 37 to 43, characterized in that the cooling and solidifying of the carbon dioxide by the second apparatus is performed by causing gas containing the carbon dioxide to contact the outside of a coolant flow pipe provided in the pressure-resistant container through which coolant flows.

45. The exhaust gas processing system according to any one of claims 37 to 44, characterized in that the coolant flow pipe is arranged to be serpentine.

46. A method of separating carbon dioxide, characterized by comprising:

making gas containing carbon dioxide flow through a pressure-resistant container to cool and solidify the carbon dioxide;

closing the pressure-resistant container air-tightly;

raising in temperature the solidified carbon dioxide to vaporize;

liquefying the carbon dioxide by pressure increase due to the vaporization of the carbon dioxide in the pressure-resistant container; and

discharging the liquefied carbon dioxide outside the pressure-resistant container.

47. The method of separating carbon dioxide according to claim 46, characterized in that the cooling and solidifying is performed by causing gas containing the

carbon dioxide to contact the outside of a coolant flow pipe provided in the pressure-resistant container through which coolant flows.

5 48. The method of separating carbon dioxide according to claim 47, characterized in that the coolant flow pipe is arranged to be serpentine.

10 49. The method of separating carbon dioxide according to claim 46, characterized in that the raising in temperature of the solidified carbon dioxide is performed by a heat transfer pipe or an electric heater provided in the pressure-resistant container.

15 50. The method of separating carbon dioxide according to claim 46, characterized in that the pressure-resistant container comprising:

a gas inlet which lets gas containing the carbon dioxide flow into the pressure-resistant container;

20 a gas outlet through which gas in the pressure-resistant container is discharged outside the pressure-resistant container; and

a liquid outlet through which the liquefied carbon dioxide is discharged outside the pressure-resistant
25 container.

51. The method of separating carbon dioxide according to claim 46 or 47, characterized in that the gas includes nitrogen oxides or sulfur oxides.

52. A method of separating carbon dioxide which uses a pressure-resistant container having a gas inlet to let gas flow into it, a gas outlet to let gas therein be discharged, and a liquid outlet to let liquid therein be discharged; a cooler provided in the pressure-resistant container; and a heat transfer device to raise in temperature the inside of the pressure-resistant container, characterized by comprising:

10 letting gas containing carbon dioxide flow into the pressure-resistant container through the gas inlet;
 causing the gas to contact the cooler, thereby cooling and solidifying the carbon dioxide;
 closing the gas inlet and gas outlet, thereby closing
15 the pressure-resistant container air-tightly;
 raising in temperature the solidified carbon dioxide to vaporize with use of the heat transfer device;
 liquefying the carbon dioxide by pressure increase due to the vaporization of the carbon dioxide in the
20 pressure-resistant container; and
 discharging the liquefied carbon dioxide outside the pressure-resistant container through the liquid outlet.

53. An apparatus of separating carbon dioxide characterized by comprising:

25 a pressure-resistant container having a gas inlet to let gas flow into it, a gas outlet to let gas therein be discharged, a liquid outlet to let liquid therein be discharged, a control valve to control the amount of gas
30 flowing in through the gas inlet, a control valve to

control the amount of gas being discharged through the gas outlet, and a control valve to control the amount of liquid being discharged through the liquid outlet;

5 a cooler provided in the pressure-resistant container; and

a heat transfer device that raises in temperature the inside of the pressure-resistant container.